



RESPONSE ACTION CONTRACT
FOR REMEDIAL, ENFORCEMENT OVERSIGHT, AND NON-TIME
CRITICAL REMOVAL ACTIVITIES AT SITES OF RELEASE OR
THREATENED RELEASE OF HAZARDOUS SUBSTANCES IN REGION VIII

Prepared for:
U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION IV


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FINAL
REMEDIAL INVESTIGATION REPORT
FOR
OPERABLE UNIT 4
WOOLFOLK CHEMICAL WORKS SUPERFUND SITE
FORT VALLEY, GEORGIA

OCTOBER 18, 2002

U.S. EPA CONTRACT NO. 68-W5-0022
WORK ASSIGNMENT NO. 976-RICO-04W1
DOCUMENT CONTROL NO. 3282-976-PP-WKPN-15843

Prepared By:

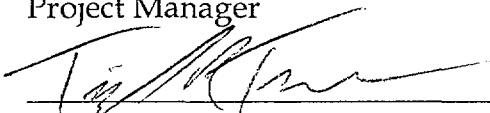


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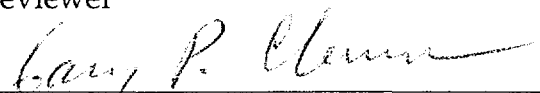


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Acronyms and Abbreviations

ADD	average daily dose
AES	Applied Engineering Sciences
AOC	Order of Consent
ARAR	applicable, relevant, or appropriate requirement
ATSDR	Agency for Toxic Substances and Disease Registry
BAP	benzo(a)pyrene
bgs	below ground surface
BRA	baseline risk assessment
BRA-HH	baseline risk assessment for human health
CDM	CDM Federal Programs Corporation
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CGC	Canadyne-Georgia Corporation
CLP	Contract Laboratory Program
COC	contaminant of concern
COPC	contaminant of potential concern
CPAH	carcinogenic PAH
CPPP	Coastal Plain Physiographic Province
CSESI	Clean Sites Environmental Services, Inc.
CSF	cancer slope factor
CSM	conceptual site model
DDD	1,1-dichloro-2,2-bis(p-chlorophenyl)ethane
DDE	1,1-dichloro-2,2-bis(p-chlorophenyl)ethylene
DDT	1,1,1-trichloro-2,2-bis(p-chlorophenyl)ethane
DMA	2,4-dimethylamine
DQO	data quality objective
EISOPQAM	Environmental Investigations Standard Operating Procedures and Manual
EPA	U.S. Environmental Protection Agency
FASP	Field Analytical Screening Program
FS	feasibility study
GAEPD	Georgia Environmental Protection Division
GNHP	Georgia Natural Heritage Program
HEAST	Health Effects Assessment Summary Tables
HI	hazard index

HQ	hazard quotient
ICP	inductively coupled plasma
IRIS	Integrated Risk Information System
K_d	soil-water partition coefficient
K_{oc}	organic carbon/water partition coefficient
LADD	lifetime average daily dose
LOAEL	lowest-observed-adverse-effect-level
m	meter
mg/kg	milligrams per kilogram
mL/g	milliliters per gram
MLK Jr.	Martin Luther King, Jr.
MMA	methylamine
NCP	National Contingency Plan
ng/kg	nanograms per kilogram
NOAEL	no-observed-adverse-effect-level
NPL	National Priorities List
OU	operable unit
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCPI	Peach County Properties, Inc.
ppm	parts per million
PRG	preliminary remediation goal
PRP	potentially responsible party
QA	quality assurance
QC	quality control
RAGS	Risk Assessment Guidance for Superfund
RBC	risk-based concentration
RfC	reference concentration
RfD	reference dose value
RfDi	RfD for inhalation exposure
RGO	remediation goal option
RI	remedial investigation
RME	reasonable maximum exposure
ROD	Record of Decision
RPD	relative percent difference
RPM	Remedial Project Manager

RSD	relative standard deviation
SAP	sampling and analysis plan
SERA	screening-level ecological risk assessment
SESD	Science and Ecosystem Support Division
SQL	sample quantitation limit
SVOC	semivolatile organic compound
TAL	Target Analyte List
TCDD	tetrachlorodibenzo-p-dioxin
TCL	Target Compound List
TEF	toxic equivalence factor
TEQ	toxicity equivalent
TIC	tentatively identified compound
TOC	total organic carbon
UAO	Unilateral Administrative Order
µg/kg	microgram per kilogram
USACE	United States Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geologic Survey
VOC	volatile organic compound
WCW	Woolfolk Chemical Works

Section 6

Contaminant Fate and Transport Analysis

An evaluation of the potential environmental fate and transport of site-related contaminants is important in determining the potential for exposure to the contaminants. There are several mechanisms by which contaminants may migrate at the WCW site from the former facility (OU-3) and off-facility surface soils (OU-4).

From OU-3, migration into the air can occur via volatilization or dust generation. Transport to surface soils in the area can occur from leaching into rainfall and subsequent surface water runoff. Migration into groundwater can occur by percolation of infiltrating rainwater or groundwater flow through waste materials or contaminated soils. Other potential mechanisms for contaminant migration may include spillage along the railroad track during on-loading/off-loading operations at the former facility, and physical tracking via foot traffic of former employees.

From OU-4, migration into the air can occur via fugitive dust emissions from contaminated surface soils. Transport from contaminated surface soils to additional surface soils can occur from leaching into rainfall and subsequent surface water runoff.

The mechanisms of migration for the COCs detected at the OU-4 site (see Section 5) are discussed in more detail below. Estimates of the physical and chemical properties of the COCs which may affect contaminant migration are presented in Table 6-1. The general persistence of the COCs is also discussed below.

6.1 Contaminant Migration

6.1.1 Air Migration

Generally, volatilization from soil and/or water into air may be an important transport mechanism for organic chemicals with Henry's Law Constants greater than 10^{-5} atm-m³/mole and molecular weights less than 200 g/mole. Henry's Law Constant is defined as the ratio of the partial pressure of a compound in air to the concentration of the compound in water at a given temperature under equilibrium conditions. None of the three organic COCs found at the site meet these two criteria. Thus, for all three of the organic COCs, volatilization is not considered an important release mechanism at this site; however, as environmental contaminants, these compounds along with the inorganic COCs are also associated with particulate matter. For this reason, the air release mechanism for pesticides and inorganics at the site would not be associated with volatilization, but rather with

Table 6-1 (page 1 of 2)

Table 6-1 (page 2 of 2)

the movement of particulate matter as airborne particles generated by wind blown dusts from contaminated surface soils.

Fugitive dust emissions from wind erosion or mechanical disturbances may occur from unpaved or unvegetated areas of the site. The environmental factors that influence wind erosion are wind speed, moisture content, vegetative cover, and soil composition. Because the environmental factors at the WCW OU-4 site are conducive to wind erosion, each of the COCs detected in surface soil is susceptible to migration via fugitive dust generation.

At the WCW OU-4 site, the presence of inorganics (primarily arsenic) in both surface soils and attic dust samples collected at the site suggests that airborne migration via fugitive dust emissions is an active release mechanism.

Release of arsenic into the atmosphere from anthropogenic sources can result from agricultural chemicals such as those produced at the WCW site. Most human releases are to land or soil, primarily in the form of pesticides or solid wastes. Arsenic in the atmosphere exists as particulate matter, mostly as particles less than 2 μm in diameter (Coles et al. 1979). These particles are transported by wind and air current until they are returned to earth by wet or dry deposition. The residence time of particulate-bound arsenic depends on particle size and meteorological conditions, but a typical value is about 9 days (EPA 1982a). Arsenic is released into the atmosphere primarily as arsenic trioxide or, less frequently, in one of several VOCs, mainly arsines (EPA 1982a). Trivalent arsenic and methyl arsines in the atmosphere undergo oxidation to the pentavalent forms (EPA 1984), and arsenic in the atmosphere is usually a mixture of the trivalent and pentavalent forms (EPA 1984, Scudlark and Church 1988). Extensive monitoring data are available for total arsenic in all environmental media; however, few studies have monitored individual arsenic species in air, water, or soil. Photolysis is not considered an important fate process for arsenic compounds (Callahan et al. 1979).

The pesticides detected in soil at the site are weakly volatile due primarily to their relatively high molecular weights and low water solubilities, which tends to make them adsorb to soils and sediments.

6.1.2 Soil Migration

Contaminants present in surface and subsurface soils may leach to the underlying aquifer. Many factors influence the rate of contaminant movement through soils. These include the physical/chemical properties of the contaminants [e.g., solubility, density, pH, viscosity, organic carbon/water partition coefficient (K_{oc})], and the physical/chemical properties of the environment (e.g., rainfall percolation rate, soil

permeability, porosity, particle size distribution, organic carbon content). The soil K_{oc} is defined as the ratio of the solute concentration in the water-saturated soil organic carbon phase to the solute concentration in the water phase. Because all the above factors can affect the rate of contaminant movement through soils, it is very difficult to predict such movement; however, based on the data collected in this RI, some gross generalizations of this movement can be made.

It should be noted, that the soil-water partition coefficient for metals is highly dependent on pH. Under low pH conditions, the soil-water partition coefficient for metals is significantly reduced thus rendering them more mobile in soils. However, while it has been well documented that industrial production activities have contributed to a low pH of onsite soils and thus facilitated the migration of contaminants both horizontally and vertically, low pH in offsite surface soils, specifically in the residential areas has not been confirmed.

Sorption of a chemical to soil particles is the only significant hinderance of contaminant migration in soils at the WCW OU-4 site. If it were not for sorption, rainfall recharge, and soil permeability at this site, the COCs would readily move downward through the soils. Sorption of contaminants is generally described by their soil-water partition coefficients (K_d). The K_d can be expressed as:

$$K_d = \frac{\text{mass of contaminant on the solid phase per mass of solid phase}}{\text{concentration of solute in solution}}$$

Estimates of the K_d for the COCs at the site are presented in Table 6-1. The total organic carbon (TOC) results and fraction of organic carbon calculations are presented in Table 6-2. The TOC laboratory analytical results are presented in Appendix I. In general, K_d values greater than 10 milliliters per gram (mL/g) indicate significant sorption potential and thus limited propensity to leach from soils to groundwater. As indicated in Table 6-1, all four of the inorganic COCs (arsenic, iron, lead, manganese), and three organic COCs (alpha-chlordane, chlordane, dieldrin) at this site have K_d values greater than 10 mL/g. Thus, in general, these contaminants are expected to readily sorb to soil particles at the site. However, the observance of some of these COCs in groundwater at or near the former facility (OU-3) at significant concentrations indicates that (1) the abundance of these contaminants in soil may have been too high for complete sorption to occur (i.e., the soil concentrations were high enough such that a significant amount of the contamination could still leach into groundwater), (2) the conditions in the soil matrix where the contaminants were found are not the same as those used to estimate the K_d , and/or (3) the contaminants are naturally occurring within the groundwater matrix. Nevertheless, leaching of these COCs from soils to

Table 6-2

groundwater at OU-4, in general, is expected to be relatively limited due to their high propensity for sorption.

6.1.3 Surface Water Migration

Contaminant migration into the drainage ditch, Falls Branch Tributary, and Big Indian Creek may occur through surface water runoff and/or through groundwater discharge. The extent of groundwater contamination at the WCW site is unknown and is currently being investigated under a separate OU (OU-1). Upon reaching these surface water pathways, contaminants may remain in the water column, volatilize, or sorb to bottom or suspended sediments. VOCs, none of which were identified as COCs, tend to quickly volatilize into the atmosphere upon reaching surface waters and for this reason are rarely observed at detectable concentrations in surface water samples. All of the SVOC COCs, including the pesticides, have low water solubilities, high K_{oc} values, and tend to associate with sediments. It should be noted, however, that association of contaminants with sediments does not preclude the migration of these contaminants since the contaminated sediments may be conveyed downstream from the drainage ditch to Falls Branch Tributary and eventually Big Indian Creek via sediment transport mechanisms during storm events.

The potential behavior of the inorganic COCs in the drainage ditch at the site is affected by pH, temperature, and hardness. Inorganic compounds can occur in aquatic systems as dissolved ions, dissolved complexes with organic and inorganic chemicals, colloids, or particulates. The solubility and mobility of the inorganic contaminants is enhanced by their ability to form complexes with humic and fulvic acids, carbonates, hydroxides, and phosphates. Because of the high K_d coefficients, the majority of the inorganic contamination would be expected to sorb to sediment particles when released to the drainage system; however, the geochemical processes in surface water identified above will also likely allow for some of the inorganic contamination to remain or dissolve in the water column. How much dissolves and how much sorbs to sediment particles will depend on the geochemical conditions of the drainage ditch, which may vary temporally and spatially. Again, however, the sorbing of contaminants to sediment particles does not preclude the migration of these contaminants since the contaminated sediments may be still be conveyed downstream to Falls Branch Tributary and eventually Big Indian Creek via sediment transport mechanisms, particularly during storm events.

6.2 Contaminant Persistence

Persistence is the measure of how long a chemical will exist in the environment before it degrades or transforms, either chemically or biologically, into some other

chemical. Some of the factors which affect the persistence of a chemical include the state of the chemical, the availability of the chemical, exposure to sunlight, oxygen availability, the types and quantities of microorganisms present, availability of nutrients, temperature, pH, as well as the presence of other chemicals which may inhibit or enhance degradation. Usually, persistence is expressed in terms of a chemical half-life and can be on the order of days, weeks, or years.

Because of the many complex factors which may affect persistence, the actual rate of chemical degradation is very difficult to predict for a given chemical at a given site, especially without the benefit of any degradation data collected from site-specific field studies. However, a qualitative evaluation of the potential for degradation of a chemical can be made based on the results of laboratory and/or field studies conducted previously at other locations. Such a qualitative evaluation was conducted for the COCs detected at the WCW OU-4 site, and the results are summarized in Table 6-3. In this table, the degradation potential for each of the COCs is indicated for the following three environmental media categories:

- **Atmospheric Degradation**—A chemical released to the atmosphere may degrade by such processes as photolysis and/or reactions with the hydroxyl radical, ozone, or other chemicals present.
- **Aquatic Degradation**—A chemical released to fresh, marine, or estuarine surface waters may degrade by such processes as photolysis, hydrolysis, oxidation, and/or biodegradation.
- **Terrestrial Degradation**—A chemical released to soil or groundwater may degrade by such processes as hydrolysis, oxidation, and/or biodegradation.

As indicated in Table 6-3, of all the COCs at the WCW OU-4 site, the inorganics have the least potential to degrade in all media and, therefore, will likely persist the longest at the site. In fact, these contaminants, under ordinary conditions, will likely persist indefinitely (for all practicable purposes).

Arsenic in soil exists in various oxidation states and chemical species, depending upon soil pH and redox potential. Arsenate [As(V)] and arsenite [As(III)] exist as oxyanions in oxidized systems, while metallic arsenic [As(0)], arsine [As(-III)], and methylated forms of arsenic are thermodynamically stable in reduced systems such as swamp and bogs. The arsenate and arsenite oxyanions can have various degrees of protonation depending upon pH (EPA 1982a, McGeehan 1996).

Table 6-3

As(V) predominates in aerobic soils and As(III) predominates in slightly reduced soils (e.g., temporarily flooded) (EPA 1982a). Transformations between the various oxidation states and species of arsenic occur upon the arsenic species and the oxidation state. Arsenite is of environmental concern because it is much more toxic than arsenate and is much more mobile in soil systems (McGeehan 1996).

Organoarsenical pesticides [e.g., methylamine (MMA), 2,4-dimethylamine (DMA)] applied to soil are metabolized by soil bacteria to alkylarsines, arsenate, and MMA.

Arsenicals can also be mineralized to inorganic arsenic; however, as previously mentioned, the interconversion of the various arsenic species and transport among the environmental media is complex and not all aspects are well-studied.

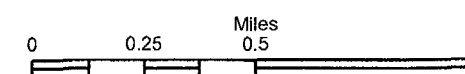
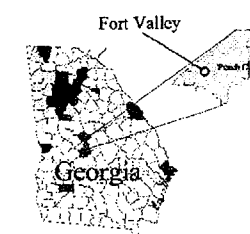
Arsenic in water can undergo a complex series of transformations, including oxidation-reduction reactions, ligand exchange, and biotransformation (Callahan et al. 1979, EPA 1984a, Welch et al. 1988). Rate constants for these various reactions are not readily available, but the factors most strongly influencing fate processes in water include Eh (the oxidation-reduction potential), pH metal sulfide and sulfide ion concentrations, iron concentrations, temperature, salinity, and distribution and composition of the biota (Callahan et al. 1979, Wakao et al. 1988). No formation of arsine gas from marine environments has been reported (Tamaki and Frankenberger 1992).

In aquatic systems, inorganic arsenic occurs primarily in two oxidation states. As (V) and As (III) oxidation states are considered more toxic to humans than the As (V) state (Aurillo et al. 1994). In general, As(V) predominates under oxidizing conditions and As(III) predominates under reducing conditions; however, the reduction of arsenate to arsenite is slow so arsenate can be found in reducing environments. Conversely, arsenite can be found in oxidizing environments (Mariner et al. 1996). In the pH range of natural waters, the predominant aqueous arsenate species are H_2SO_4 and HAsO_4^{2-} . The predominant arsenite species is H_3AsO_3 (Aurillo et al. 1994). The predominant form of arsenic in surface waters is usually arsenate (EPA 1982b), but aquatic microorganisms may reduce the arsenate to arsenite and a variety of methylated arsenicals (Aurillo et al. 1994, Benson 1989, Braman and Foreback 1977, Edmonds and Francesconi 1987, Gao and Bureau 1997). Both reduction and methylation of As(V) may lead to increased mobilization of arsenic since As(III), dimethylarsinates, and monomethylarsonates are much less particle-reactive than As(V) (Aurillo et al. 1994). Arsenate often predominates in groundwater, but arsenite may be an important component, depending upon the characteristics of the water and surrounding geology (Robertson 1989, Welch et al. 1988).

Other chemicals which also have low to moderate degradation potential, particularly in aquatic and terrestrial environments, include the OU-4 pesticide COCs alpha-chlordane, chlordane, and dieldrin. These pesticides generally have low to moderate potentials for degradation, unless released to the atmosphere, in which case they have a higher potential for degradation.



Figure 2-2
Operable Unit 4 (OU4) Site Location Map
Woolfolk Chemical Works Site OU4 RI/FS
Fort Valley, Georgia



CDM

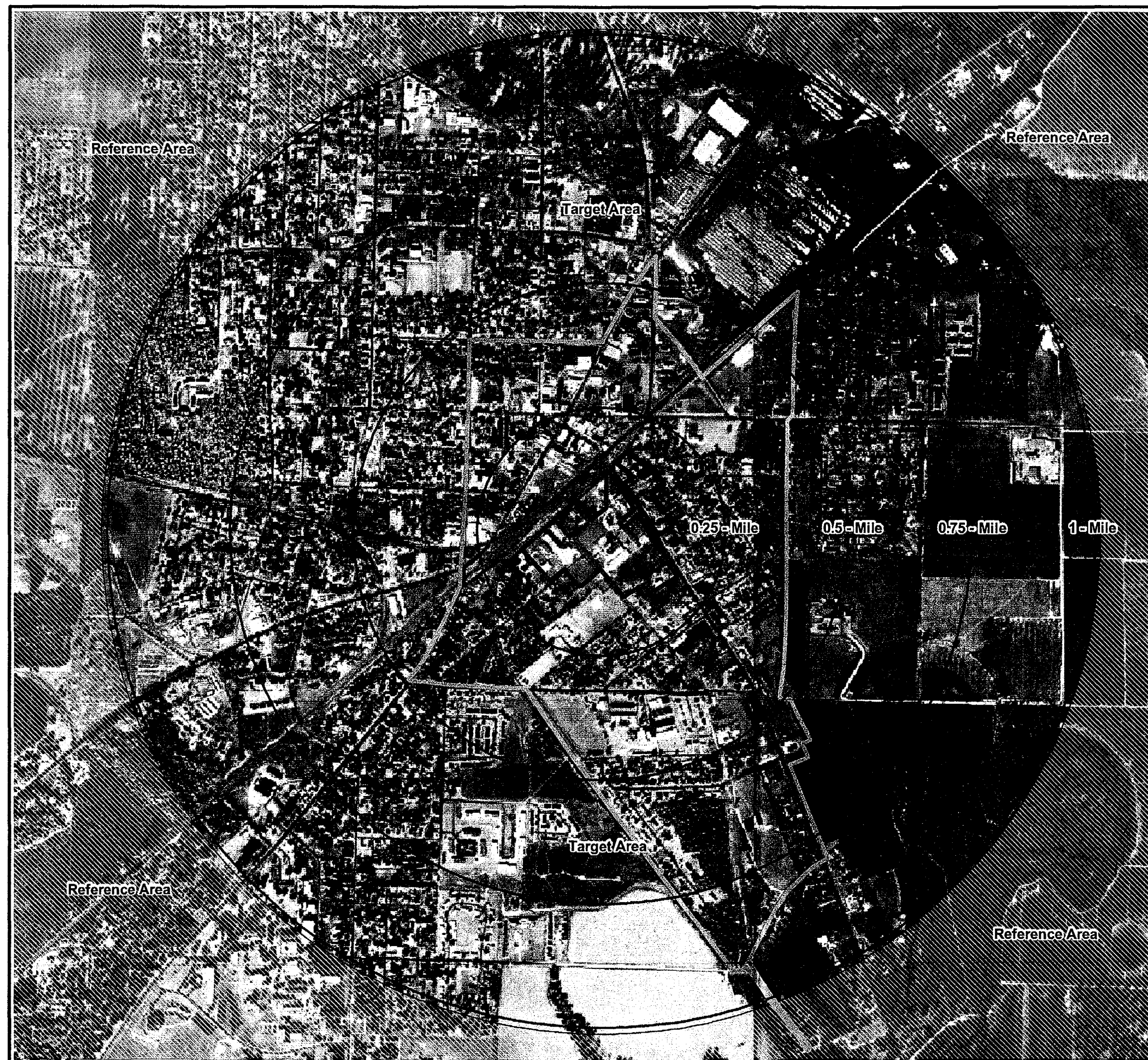






Figure 3-1
Reference/Target Area Map
Woolfolk Chemical Works Site OU4 RI/FS
Fort Valley, Georgia

Legend

-  Reference Area
-  Operable Unit 2 Boundary
-  Operable Unit 3 Boundary
-  Operable Unit 4 Boundary



CDM



Figure 3-2
Phase I Sample Location Map
Woolfolk Chemical Works Site OU4 RI/FS
Fort Valley, Georgia

Legend

- CDM Sampling Location (OU4 RI)
- Operable Unit 3
- Operable Unit 2
- Parcel Boundaries
- OU4 Subarea Boundaries



CDM

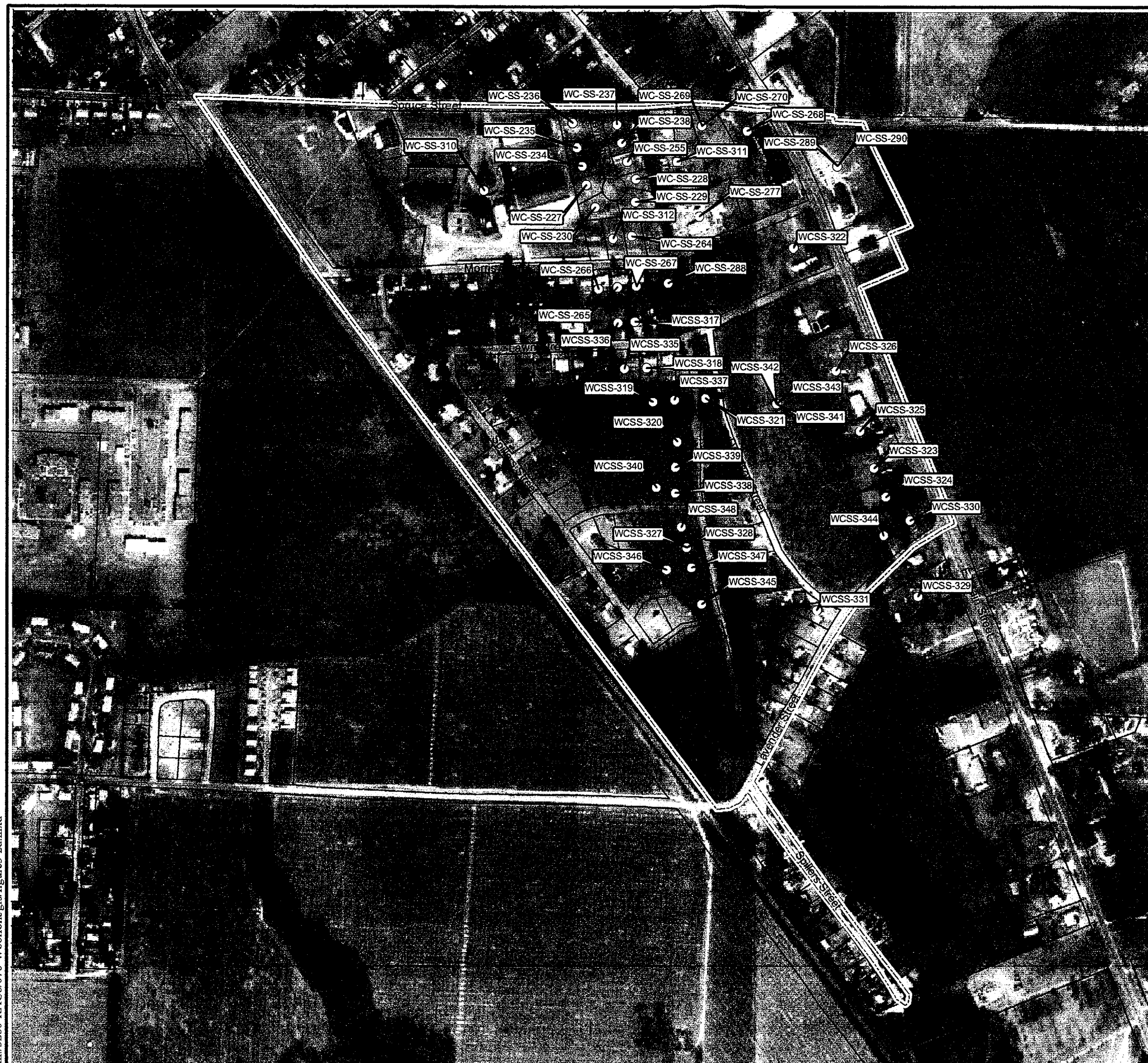
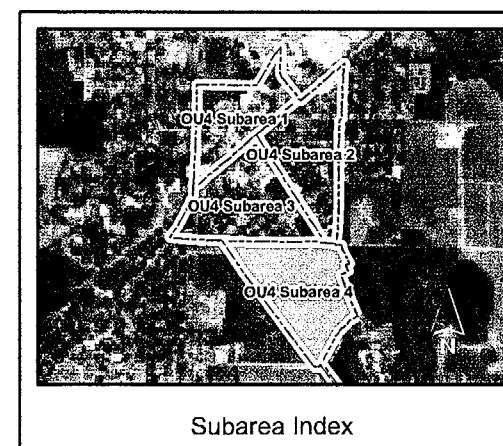
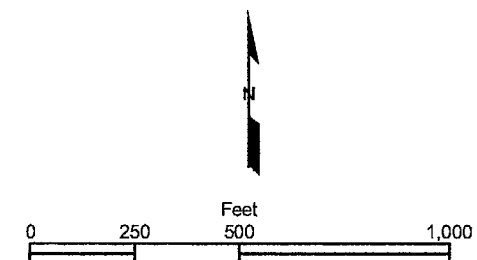


Figure 3-2d
Phase I Sampling Locations
Subarea 4
Woolfolk Chemical Works Site OU4 RI/FS
Fort Valley, Georgia

Legend

- CDM Federal Sample Locations
- Operable Unit 3
- Operable Unit 2
- Parcel Boundaries
- OU4 Subarea Boundary

Sample Locations are a composite of
5 discrete samples which represents
the parcel.



CDM

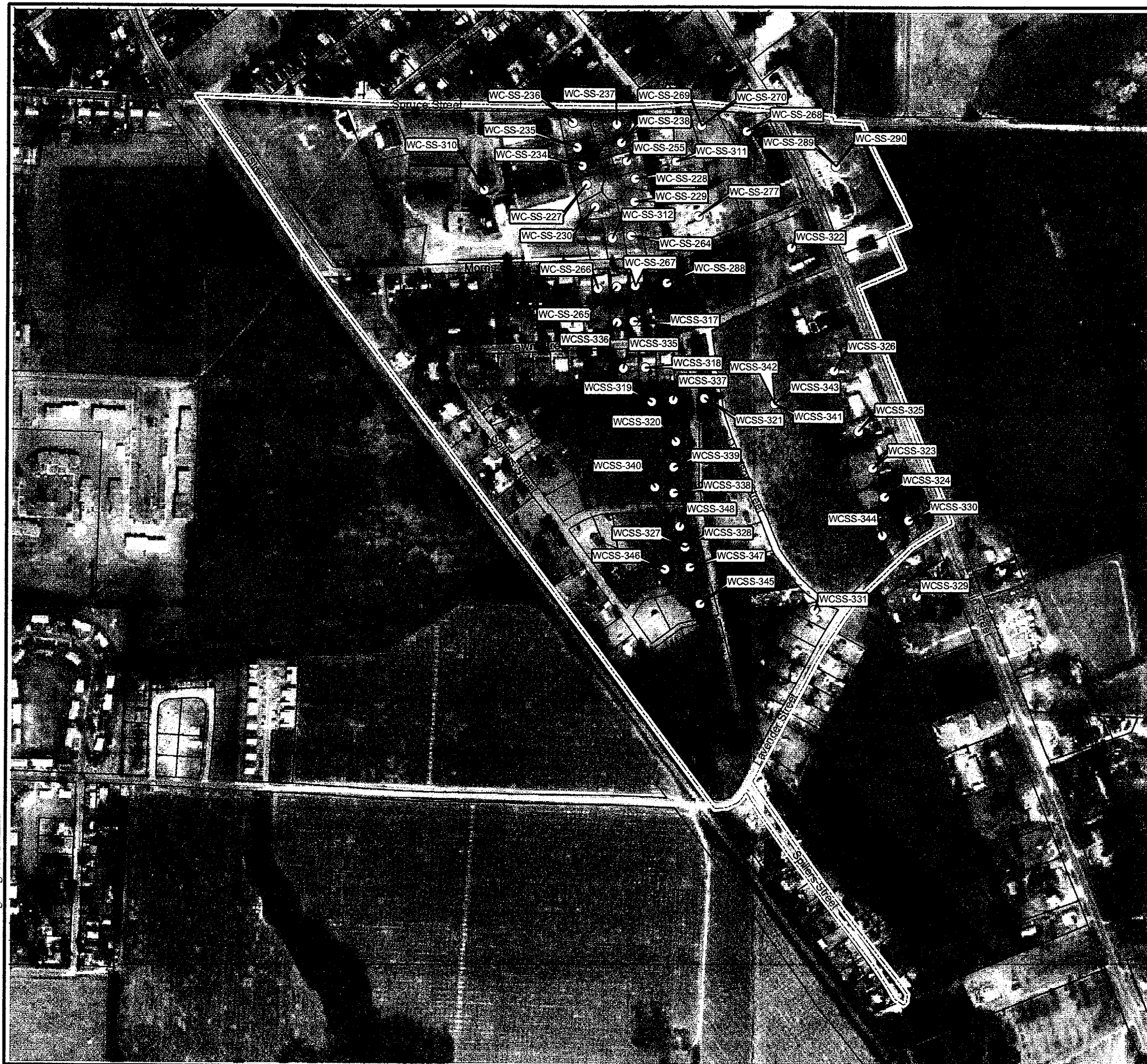
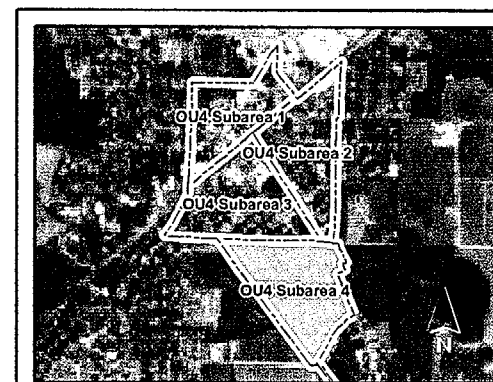
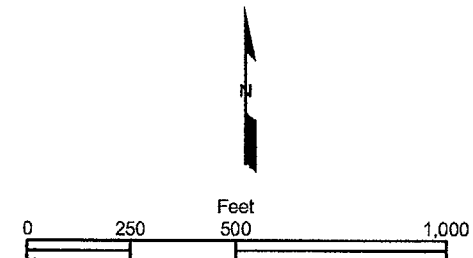


Figure 3-2d
Phase I Sampling Locations
Subarea 4
Woolfolk Chemical Works Site OU4 RI/FS
Fort Valley, Georgia

Legend

- CDM Federal Sample Locations
- Operable Unit 3
- Operable Unit 2
- Parcel Boundaries
- OU4 Subarea Boundary

Sample Locations are a composite of
5 discrete samples which represents
the parcel.



Subarea Index

CDM

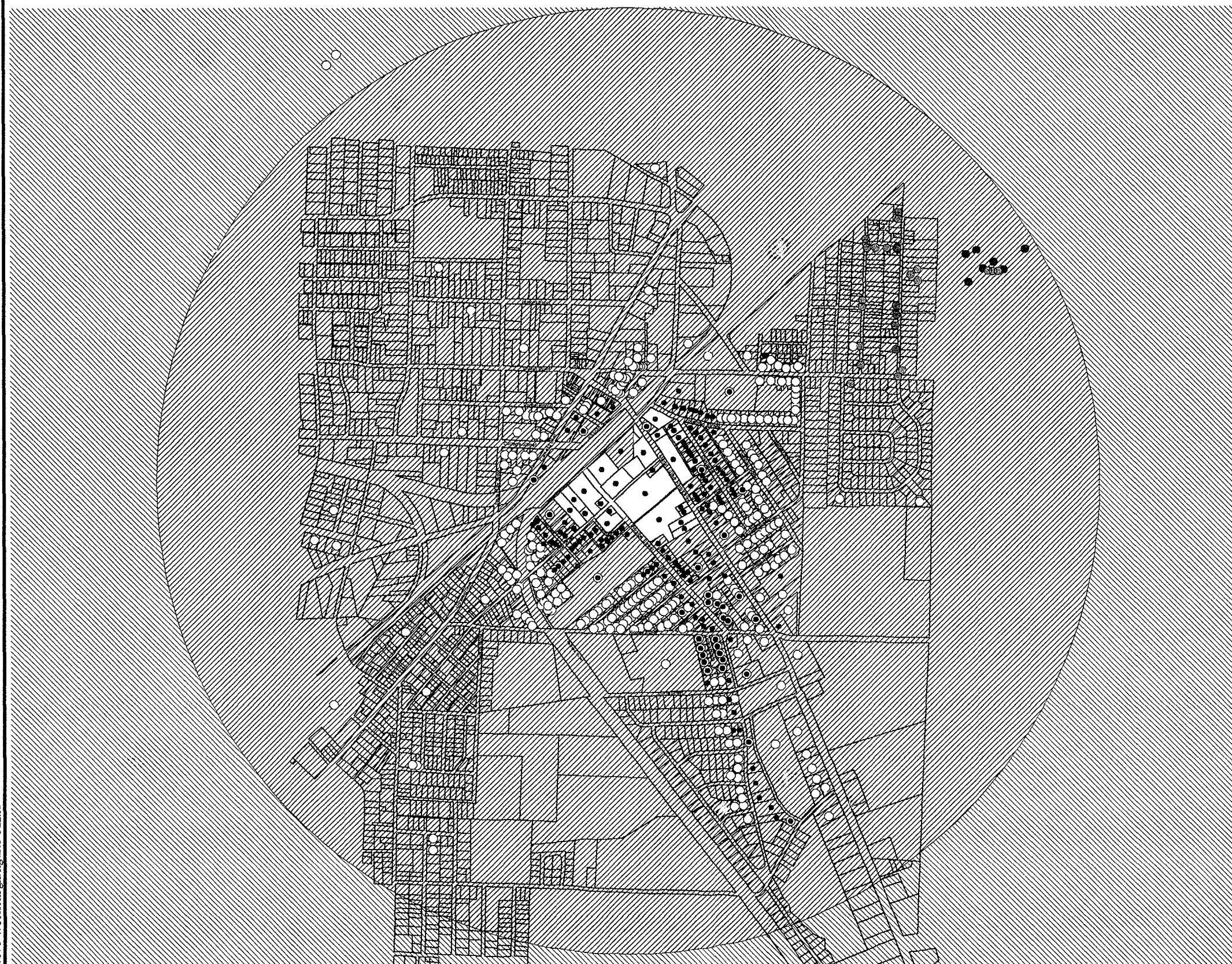
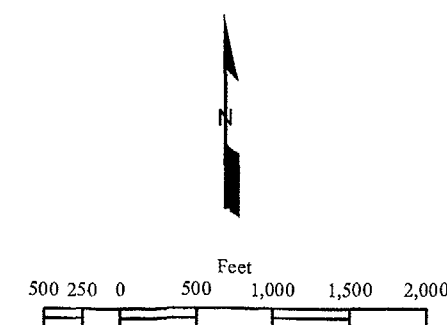


Figure 3-5
CDM Federal, ATSDR, Georgia EPD,
CH2M Hill and EPA Sampling Locations
Woolfolk Chemical Works Site OU4 RI/FS
Fort Valley, Georgia

- Legend**
- CDM Sampling Location (OU4 RI)
 - ⊙ ATSDR (Griffin Line Community 6/00, 8/00)
 - CH2M Hill and EPA (1/98, 2/95, 03/94, 04/94, 07/94, 9/94, 10/93, 12/93)
 - Georgia EPD (Vienna Street Dump/Indian Oak Apartments 8/00)
 - ▨ Operable Unit 3
 - ▧ Operable Unit 2
 - ▨ Reference Area
 - ▨ Target Area
 - ▭ Parcel Boundaries



CDM

U . S . E P A R E G I O N I V

SDMS

Unscannable Material Target Sheet

DocID: 10084689 Site ID: GAD003269578

Site Name: Woolfolk Chemical Works, Inc

Nature of Material:

Map:	<u>1</u>	Computer Disks:	_____
Photos:	_____	CD-ROM:	_____
Blueprints:	_____	Oversized Report:	_____
Slides:	_____	Log Book:	_____

Other (describe): Figure 4-3: Map of Parcels Affected by Arsenic

Amount of material: Contamination

Please contact the appropriate Records Center to view the material.

U . S . E P A R E G I O N I V

SDMS

Unscannable Material Target Sheet

DocID: 10084689 Site ID: GAD003269578

Site Name: Woolfolk Chemical Works, Inc.

Nature of Material:

Map:	<u>1</u>	Computer Disks:	_____
Photos:	_____	CD-ROM:	_____
Blueprints:	_____	Oversized Report:	_____
Slides:	_____	Log Book:	_____

Other (describe): Figure 7-1: Parcels equal to or greater
Amount of material: than 20 mg/kg Arsenic.

Please contact the appropriate Records Center to view the material.